DRAFT

Rev 03 10/2/95

DEVELOP SYSTEM REQUIREMENTS

1. Description:

Developing system requirements is the process of translating an operational need into system functional, performance, and interface requirements through a process of analysis, decomposition and allocation. Design alternatives are developed to sufficient detail to permit assessments to be made which can demonstrate that the functional baseline is achievable within program constraints.

The Process Template, Figure 1, provides an overview of the process and its interactions with other elements of the team.

2. Purpose:

To formally establish for new systems or major upgrades to existing systems, the functional baseline defining the "best set" of functional, performance and interface requirements a system must meet. The process must demonstrate that the requirements can be implemented to satisfy both user needs and programmatic constraints including schedule, cost and risk.

* Requirements need to be both "streamlined" and "tailored" to meet user needs in a cost-effective manner and live within program constraints
* Meeting user needs are paramount. when programmatic constraints compromise the attainment of user needs, the issue should be raised to the Program Manager.
* Trade-off studies should be performed to determine the most cost-effective, affordable alternative for meeting user needs, within programmatic constraints.
* Pre-Planned Product Improvement (P^3I) is an approach for eventually fully meeting user needs even though the initial system is unable to fully meet the needs because of technological or programmatic constraints.

3. Owner:

This process is owned by System Engineering Development/Integration [4.1.2]. It will usually have a broad range of participants as described in the Template (Figure 1) and the Deployment Flowchart (Figure 2).

4. Agents:

NAWCAD [4.1 and 4.x]; Expert team.

5. Preceding Process(es):

Determine Mission Need.

Figure 1 The Process Template

PRECEDING PROCESS
Determine Mission Need

DEVELOP SYSTEM REQUIREMENTS

NEXT PROCESS
Develop System Design

PURPOSE To establish the Functional Baseline defining the "best" set of technical requirements the system must meet in order to satisfy user needs and program constraints.

CRITICAL Essential to providing quality and cost-effective products.

INPUTS (SUPPLIERS)
- MNS/ORD [OPNAV via PM]
- PMP {PM]
- Technology Base [4.3 & 4.5]
- MOEs [4.1]
- TWP [4.1.1]
- Results from C/E phase.
- COEA results.
- Baseline Platform Data.

PRIMARY SUB-PROCESSES
- Analyze User Needs
- Identify Customer Constraints
- Define Top Level System Requirements
- Develop Preliminary Detail Design Alternatives
- Assess System Requirement Alternatives
- Prepare System Specification

OUTPUTS (CUSTOMERS)
- Design Reference Mission Profiles [4.1.1, 4.x]
- TPMs [4.1.1, 4.x]
- Functional Baseline Specifications [1.0]
- System Design Alternatives [1.0]
- Cost Estimate(s) [4.1.1]
- Schedule Data [4.1.1]
- Risk Assessment [4.1.1]
- Trade Study Reports [4.1.1]
- Engineering Analysis Reports [4.1.1, 4.x]

ENTRY CRITERIA
- Completion of Milestone 0
- Tasking and funding from sponsor [4.1.1]

SUPPORTING SUB-PROCESSES
- Conduct Trade Studies [4.x]
- Implement Requirements Traceability [4.1.1]
- Establish and Maintain Decision Database [4.1.1]
- Perform Cost Analyses [4.2]
- Assess Effectiveness of Alternatives [4.J]
- Perform COEA [4.J]
- Conduct Technical Reviews [4.J]

EXIT CRITERIA
Approved functional baseline by the customer.

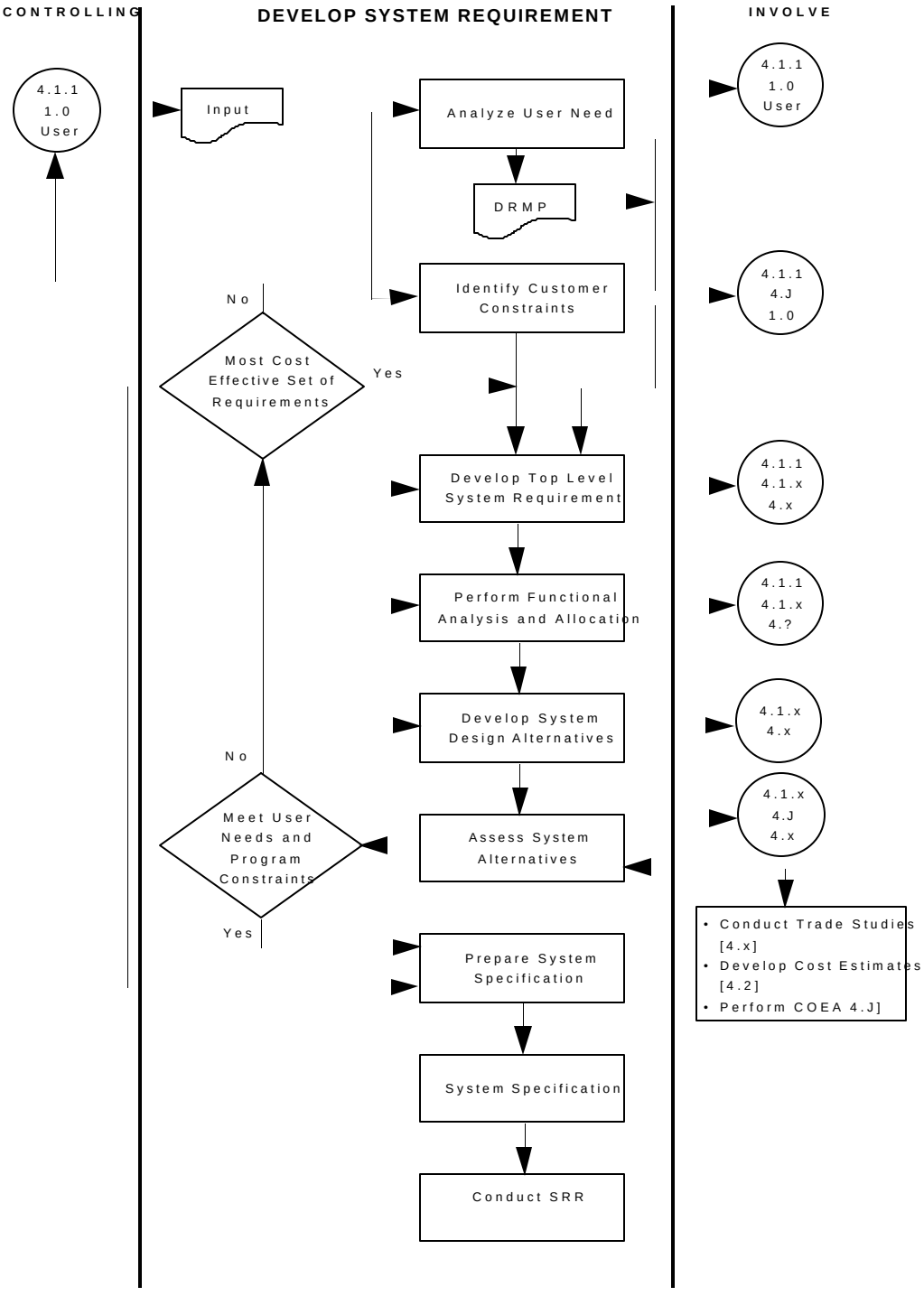
AGENTS
4.0 with support from appropriate 4.1 elements and appropriate 4.x elements.

TOOLS
Requirements analysis and management tools. (TBD)

HANDBOOKS, STANDARDS, LIMITS

METRICS AND MEASURES
Number of: Orphan Requirements; Requirement that specify a design solution; Conflicting Requirements; Missing Requirements

Figure 2 Deployment Flowchart



It has been determined that there is a mission need which is not being met and either a new system or an upgrade to an existing system is required.

6. Inputs And Suppliers:

Available inputs may include:

MNS [1.0]

An MNS will normally be approved at this stage.

Probable a draft ORD [1.0].

Ideally the ORD development and this process should be performed as an integrated effort, with this process defining the technical requirements associated with the operational requirements and the cost, schedule and risk associated with meeting the technical/operational requirements. COEA results may also be an input. The COEA may also be employed as the method for establishing operational and technical requirements.

Programmatic Objectives and Constraints [1.0].

Cost, schedule and risk.

PMP [1.0].

MOEs [OPNAV via 1.0].

It is likely that previous effectiveness studies have been performed and MOEs developed that System Engineering should be aware of and use as they continue to evolve system requirements.

Baseline Platform Data [4.1.1.1].

Many efforts to develop system requirements are upgrading some existing system. Existing data when available should be used in this process to avoid needless duplication.

Technology Base [4.0T, 4.3, 4.5, etc.].

Basic and Applied Research

Results from C/E phase and related technologies from other programs.

7. Entry Criteria:

The current trend for new programs is to attempt to proceed in a more expeditious manner (to shorten development time and decrease cost), however, the objective of this process is still to

define a set of functional, performance, design and interface requirements that guide and constrain the system developer.

7.1 Required To Start:

The completion of Milestone 0 and the formulation of a TWP for the effort will classically initiate this phase of the program. For new programs, the earliest start of this process is during the CE&D phase. The definition of System Requirements should ideally be started during this phase, integrated with the COEA and Definition of Operational Requirements (resulting in an ORD) processes. In those cases where this process is started in Phase 0, it is usually not completed until Phase I (i.e., the process is executed in Phase 0 to provide enough system definition detail to adequately support the COEA and Operational Requirements definition processes and the process is executed again in Phase I to add any additional detail needed to fully support development).

For major upgrades or P^3I programs, this process may occur during Phase III to support a Milestone IV approval. This usually occurs because of one or more of the following factors:

* A change in threat or Defense Planning Guidance.
* A deficiency identified during follow-on operational testing or operational training and support.
* An opportunity to reduce the cost of ownership.

7.2 Will Cause to Start:

There are other factors which may cause the process to begin which may not be the normal or necessary condition. Examples of these are: sudden change in national defense policy, a breakthrough in technology, a sudden change in threat capability, etc.

8. Primary Subprocesses:

8.1 Overview:

The process of developing system requirements is intended to establish a verified set of system technical requirements that are derived through an iterative (and overlapping) execution of a number of sub-processes all pointed at establishing a set of system requirements that can be implemented in a manner that satisfies both the needs of the user and constraints of the program. Typically this process is executed prior to the initiation of the E&MD phase of program development. Draft versions may be developed during Concept Exploration, but will not contain the same level of detail and will allow greater latitude for exploration. Acquisition approaches involving significant NDI/COTS application may appear to move the establishment of a functional baseline closer to the Milestone III, but the general scope of the effort and intent are not really changed. The following text expands briefly on purpose and relationship of each of the subprocesses and on other elements of the Template (Figure 1).

8.2 Analyze User Needs [4.1.2]

To provide a full understanding of the user needs, missions and environments and to establish a technical description of those needs that will then serve to drive lower level requirements. This will be used throughout the process to assess whether a set of lower level requirements meet the need, as well as to continue the progressive decomposition of system requirements. An output of this effort will be the preparation of Design Reference Mission Profiles.

8.3 Identify Customer Constraints [4.1.2]

To provide a full understanding of the customer constraints which will serve as a measure of whether or not the program can be successfully executed.

The customer or sponsor for a program typically has a set of constraints that are given. These include: costs, schedules, willingness (or ability) to accept risks, commonality requirements with other systems, etc. The particulars are unique to each program. SE must seek to understand such constraints and relay these to the effort of the technical team. Whether it is applicable these program constraints should be documented in the program planning documents.

8.4 Define Top Level System Requirements [4.1.2]

To establish the framework of the system requirements in which a team can work, acknowledging the top level set of requirements from which others are derived. This will typically be an elaboration on the results of analyzing the user needs, but will begin to illustrate capabilities required of some high level functions, e.g., communications, key performance parameters, etc. The objective is to establish enough of a structure to the requirements definition that experts in their respective areas can begin to work their areas with some degree of independence.

At this point in the effort consideration shall be given to the definition of alternative sets of system requirements to perform trade-off studies.

8.5 Develop System Design [4.1.2]

To progressively decompose the top level set of requirements to a level suitable to initiate the system design effort. This will provide a more detailed definition of system requirements and additional bounding for system development. System design will be developed to a level of detail that allows adequate estimates of cost (development, production, deployment, O&S, and disposal), schedule, and risk to be made.

8.6 Develop Preliminary Detail Design Alternatives [4.1.2]

To establish sufficient preliminary design data to define design alternatives, based on alternative functional or performance requirements if there are apparent driving requirements to contend with. During this process, the team will determine what system design approaches appear favorable and which approaches can be abandoned. Each alternative to be considered is developed to a level where system performance costs, schedules and risks can be assessed.

8.7 Assess System Requirement Alternatives [4.1.2]

To provide a technical assessment as to whether a set of system requirements can be achieved within program constraints and which alternative provides the “best” set for the program.

The conduct of trade-off studies, development of program cost estimates and schedules, risk assessments and the performance of the COEA effort are all supportive to accomplishing this effort.

8.8 Prepare System Specification [4.1.2]

Although the system specification effort began back when the top level requirements were initially defined, this process will take all the requirements data developed, refine, finalize and put the data in the proper format for a system specification. This specification will be verified during this process and then be released for a System Requirements Review (SRR).

9. Supporting Subprocesses:

9.1 Conduct Trade Studies [4.x]

The conduct of trade studies is pervasive throughout the process of requirements development. As requirements definition are progressively refined and become more detailed in both number and specificity, trade studies will result in more refined and detailed comparison of alternative approaches. The ultimate solution is a search for a set of requirements that “best” satisfies both the user’s needs and the stated program constraints. The conduct of early and continuous cost-schedule-performance trade-offs are fundamental to the completion of this process.

9.2 Implement Requirements Traceability [4.1.1]

The ability to trace requirements as they are broken down and defined in much more detail is key to maintaining focus and ensuring the quality of the overall requirements development effort.

9.3 Establish and Maintain Decision Database [4.1.1]

Use this database to maintain a continuous record of how the requirements were derived, what the requirements are and why the requirements are what they are.

9.4 Perform Cost Analyses [4.2]

Cost analyses are conducted throughout the requirements development process. As the system alternatives are developed and more information becomes available, the cost analyses will also progress and mature into adequate estimates of cost.

While the system engineering team will propose system designs and provide the necessary information required for cost analyses, an independent cost group needs to perform the associated cost estimation.

9.5 Assess Effectiveness of Alternatives [4.1]

Once the alternatives have been established, the process of assessing the effectiveness of each one is initiated. Measures of effectiveness should be defined and each alternative is evaluated against a baseline. Measures of performance should relate to measures of effectiveness such that the effect of a change in the measure of performance can be related to a change in the measure of effectiveness. Measures of cost should also be defined so that each alternative can be evaluated to show how changes in these measures affect cost effectiveness.

9.6 Perform COEA [4.J]

When each alternative has been defined to a level where performance, schedule and cost information becomes available, a Cost and Operational Effective Analysis can be performed. The COEA identifies the major costs and measures of effectiveness associated with each alternative. criteria on which decisions or recommendations are to be made should be clearly identified and explained.

9.7 Conduct Technical Reviews [4.J]

There is no formal checklist for conducting technical reviews. generally, the following suggestions are offered:

* What are the problems, deficiencies?
* Is the context consistent with Defense Planning Guidance?
* Have assumptions and program constraints been identified? Are they reasonable?
* Have all reasonable alternatives been considered?
* Do the measures of effectiveness relate to the performance thresholds and objectives established for the system?
* Have all relevant costs been presented?
* Does the analysis present all costs and measures of effectiveness for all alternatives?
* Do the results look reasonable?

10. Timeline:

A timeline for this process shall be established in accordance with the unique requirements of each program, the complexity of the requirement and the program constraints established by the customer.

11. Outputs And Customers:

Design Reference Mission Profiles (DRMP) [4.1.1, 4.x]

TPMs [4.1.1, 4.x]

Functional Baseline Specifications [1.0]

* System Specification which defines the requirements for the system, defines the system interfaces and their interrelationships.
* Detail Specification which clearly states the detail system requirements without stating or implying a design and has been streamlined and tailored to the program.

System Design Alternatives [1.0], Cost Estimates [4.1.1] Schedule Data [4.1.1] Risk Assessment [4.1.1] [1.0];

Define System Design Alternatives to sufficient depth and detail that the supporting assessments on system performance, cost, schedule and risk can present a credible argument to support program decision points.

Trade Study Results [4.1.1, 1.0]
Engineering Analysis Reports [4.1.1, 4.x]

Data generated from all the trade studies and engineering analyses performed during the requirements development process which supports the technical and programmatic decisions made and which provides an historical record such that the basis for program decisions can be traced throughout the life cycle of the program.

12. Exit Criteria:

The criteria to complete the process of defining a functional baseline and proceed to the next phase is to successfully complete a Systems Requirements Review (SRR) with customer approval. Successful completion of the process will also be measured by providing sufficient data to support Milestone I (Concept Demonstration) or, if all risk reduction efforts have been completed and mature technology exists, support Milestone II (Engineering and Manufacturing Development).

13. Next Processes:

The next activity is to initiate the process of performing the actual system design. The design activities performed during the requirements development process, if successfully completed, resulted in at least one design alternative that satisfies the performance requirements and the program constraints. It is not the intent of these design activities to define an actual design for implementation. In fact, if this were so, then it would be concluded that the process was not properly executed.

14. Tools:

N2 charts, RASs and FFBDs have been used to support requirements and decomposition. They are manual tools, which can be effective, but for large systems quickly become complex to use throughout the process.

There are a number of tools in the commercial marketplace that can be used to develop and manage the definition of system requirements. These tools (primarily intended to support software requirements definition and management) support requirements analysis and aid in the definition of consistent and complete set of requirements, as well as provide traceability of the more detailed requirements back to the parent requirements.

such tools are not widely used at this due to their cost and the associated cost of training personnel in their use. Only large software requirements definition efforts, normally performed by industry, seem to employ such tools at this time.

15. Process Improvement Metrics and Measures:

Monthly Progress Reports, Quarterly Reviews, Final Requirements Report that specifies a design solution.

16. Standards and Handbooks:

MIL-STD-490
DOD Directive 5000.1 and 5000.2

17. Applicable Training and Experience:

Program Management & System Engineering courses, on-the-job training.

18. Reference Material:

18.1 General

Previous technical, planning and acquisition data generated on successfully implemented development programs.

18.2 Examples

Needs and Solutions for aerial targets
Aerial target Program Plan and Roadmap

19. Voice of the Customer:

By observing the metrics of paragraph 15 the customer would have the opportunity to determine the timely generation of requirements. If the metrics indicate that timely progress is not occurring, the customer, requirements manager and competency leader can evaluate the program to try and understand why the process is not working as effectively as it should be. Adjustments and corrective measures can then be put in place to try and correct the process.

20. Voice of the Process:

Historical data on the process will have to be collected and organized into a database to provide reference material, lessons learned and used as training material.

21. Detailed Process Description:

21.1 Analyze User Needs: [4.1.2]

Use the updated threat assessment report, the capability of current operational systems, Mission Need Statement, Operational Requirements Document and other existing program data to analyze user needs. Develop system mission profiles which will describe how the system will be used and which will help establish system performance parameters. In the past we have set system requirements and ignored how the system will be used and what mission scenarios drive the requirements. This can lead to developing a system which may not meet all user needs.

21.2 Identify Customer Constraints [4.1.2]

Identification of customer constraints can be accomplished in parallel with analysis of user needs. This information is contained in the Program Master Plan and other documents already prepared by the customer such as the MNS, ORD, etc. Constraints can be significant factors in the development of the system requirements. A program constraint can be cost, schedule, technical risk, system commonality, etc. Customer constraints can override pure requirements and result in early program critical issues which may have to be resolved before progressing to the next process. An example of a significant customer constraint would be that the customer can't afford the development of a new system and that alternate design approaches would be limited to upgrades to existing systems.

21.3 Define Top Level System Requirements [4.1.2]

Using the information developed thus far, establish the top level system requirements. These requirements will begin to define capabilities required by experts in their respective areas, such as aero performance, flight control, structures, payload performance, etc.

21.4 Develop System Design [4.1.2]

This part of the process takes the top level set of requirements and progressively breaks them down to a level suitable to begin a very preliminary system design effort. Requirements are much more detailed, critical design parameters are identified and risk assessments are made. This is an iterative process which will eventually lead to finding the best set of requirements which will meet user needs within his stated program constraints. This design effort will be developed to a level of detail that allows adequate estimates of cost (development, production, deployment, O&S, and disposal), schedule, and risk to be made. Information from the technology base, results from the C/E phase, etc. will be used for this design effort.

21.5 Develop Preliminary Detail Design Alternatives [4.1.2]

Using the preliminary design data previously developed and information from the COEA (if one was developed) and information from other Measure of Effectiveness studies, define design alternatives and approaches. During this process the team will determine which are the most favorable design approaches and which can be abandoned. At least one approach should meet all user needs and customer constraints. Not all alternatives have to meet all requirements. Once established, the acceptable alternative designs are developed to a level where system performance, costs, schedules and risks can be assessed.

21.6 Assess System Requirement Alternatives [4.1.2]

To technically assess all acceptable system alternatives to determine the best set of requirements which can be achieved within program constraints.

The conduct of trade-off studies, development of program cost estimates, risk assessments, Measure of Effectiveness studies, and the COEA effort are all supportive to accomplishing the prioritization and rating of all the system requirement alternatives.

21.7 Prepare System Specification [4.1.2]

Team members will be responsible for taking all the information developed in their respective areas, and refine, finalize and put the data in the proper format for a system specification (MIL-STD-490). The system specification will not reflect a specific system design, but will define system requirements and performance. This specification will be verified during this process and then be released for a System Requirements Review (SRR).

22. Expert Advice:

Our track record for system acquisition has not been without pitfalls and failures. The number of programs which have entered the EM&D phase and failed to achieve Full Production Release (FPR) has been too high. Those responsible for developing system requirements must accept some of the blame for this.

Too often the team that develops the requirements are not involved in the next process and the knowledge acquired during the requirements development are not passed on. This knowledge has to be documented so that the personnel involved in the next process clearly understand the requirements and there is no need or chance for clarification or misinterpretation.

22.1 Do's and Don'ts:

Do's:
Work with team members, even those with other agencies. Don't work as adversaries.
Provide and exhibit leadership with the customer.
Volunteer to do more than work assigned.

Document thoroughly, people involved in the next process have to know what is in your head. Be honest at all costs.

Don'ts:
Think things through before you disagree with the customer. Your job is to provide him support.

At the same time, do not compromise your integrity because of program constraints.

22.2 Best Practices:

22.3 Lessons Learned:

We have a tendency to develop system requirements in a rush (usually because of pressure from the customer). This almost always results in an inadequate set of requirements. And if we by chance move into EM&D prematurely, this results in requirements creep and cost growth and finally program cancellation. An example of this was the FIREBRAND program.

During the 1980's, by directive, there was a rash of fixed price contracts awarded. Some of these contracts required research and development efforts. Some of the contracts were successful and saved the Government many dollars probably at the expense of the prime contractor. Others were not successful. Prime contractors and the Government debated whether changes were new requirements or clarification of requirements, etc. As a result, many programs experienced schedule delays and cost growths due to changes in the originally defined scope of work. The AQM-127A and BQM-126A were examples of this.

Historically, aerial target programs utilized the existing technology base and at the completion of the requirements development process would proceed directly into the Engineering and manufacturing Development (EMD) phase. As the threat changed and became more sophisticated, Naval weapon systems also progressed in sophistication to counter this threat. These requirements translated to more sophistication in aerial target developments. In some instances the existing technology base did not support the new developments, however, target systems did not conduct concept demonstrations to reduce the technical risks in these programs. This resulted in the need to develop new technology during the EMD phase which resulted in cost growth and schedule delays.

22.4 Expert Wisdom:

If we do a better job of developing requirements, preliminary design and risk reduction before entering EM&D, we would save significant time and funding. One year of homework is equivalent to 4 years of wheel spinning and requirements creep during EM&D.

23. Points of Contact:

The following Personell can be contact in reference to the subject Requirements Process

Albert Ortiz	NAWCAD WAR	4.1.5	215-441-2117
Kevin Kennedy	NAWCAD WAR	4.1.5	215-441-3828
John Kichula	NAWCAD WAR	4.1.1.2	215-441-3500
Dave Tauras	NAWCAD WAR	4.1.1.2	215-441-2083
Don Dalessandro	Veda		215-672-3200 X345